samples were collected, preserved, and shipped to appropriate laboratories for analysis of:

- Benthic and sestonic chlorophyll *a*
- Identification and enumeration of relative abundance of diatom species
- Identification and enumeration of relative abundance of various benthic macroinvertebrate taxa
- Nutrients, including available forms of nitrogen and phosphorus.

At the 38 locations selected for full suite chemical analysis, the following additional parameters were analyzed by the appropriate laboratories:

- Dissolved and total metals
- General water quality parameters (sulfate, chloride, bicarbonate/carbonate)
- Bacteria
- Estrogens
- Extraction of DNA for potential PCR analyses

Samples collected at the public access recreational areas were analyzed for bacteria concentrations.

2.8.2.7 Implementation of Sampling Approach

The general sampling approach was conducted following CDM SOP 7-5 and SOP 6-1 for surface water sampling and SOP 8-1 for use of field water quality meters. All surface water samples were collected in accordance with SOP 6-1 and submitted to the relevant analytical laboratories. Also applicable to this sampling program is SOP 9-1. The CDM SOPs are presented in Darren Brown's Expert Witness Report.

2.8.2.8 Alterations to the Sampling Program

In some cases, sites initially selected for analyses were found to have insufficient flow or accessibility by the field crew. Replacement locations were identified using the same methodology as the initial sites.

2.8.2.9 Samples

A total of 296 locations were visited during the Phase 1 field program. Of these, 194 sites were sampled for a minimum of field PO4 samples and *in situ* water quality measurements. An additional 102 sites were visited but either had no available surface water or were deemed inaccessible by members of the field crew. **Table 2.8-4** summarizes the number of samples collected for each parameter during both phases of the sampling program. A total of 28 bacteria samples were collected from the public access recreational areas.

Figure 6.5-12 and **Figure 6.5-13** (introduced in previous section), show the concentrations of total phosphorus in groundwater related components. The majority of the concentrations of total phosphorus for the geoprobe samples ranged between 16 mg/L to 113 mg/L. The majority of the concentrations of total phosphorus for the spring samples ranged between 0.02 mg/L to 0.05 mg/L. The majority of the concentrations of total phosphorus for the well samples ranged between 0.005 mg/L to 0.03 mg/L. As shown in **Figure 6.5-14**, a very similar trend is observed for soluble reactive phosphorus (SRP). The majority of the concentrations of SRP for the geoprobe samples ranged between 0.003 mg/L to 0.15 mg/L. The majority of the concentrations of SRP for the spring samples ranged between 0.01 mg/L to 0.03 mg/L.

6.6.2 Distribution of Bacteria through out the Basin – Water

Surface Water: **Figures 6.6-5** through **Figure 6.6-8** are spatial representations of the average concentration of enterococci for the various sampling locations. The majority of the locations monitored had concentrations of enterococci that were greater than the reference samples. Enterococci is widespread throughout the entire basin and many average concentrations are greater than 33MPN/100mL.

As shown in **Figure 6.5-6** and **Figure 6.5-7** (introduced in previous section), the majority of the concentrations of enterococci for the EOFs range from 2200 MPN/100mL to 33000 MPN/100mL. The majority of the concentrations of enterococci for the small tributaries and the surface water stations and USGS station (baseflow) have concentrations typically ranging from 80 MPN/100mL to 800 MPN/100mL. The majority of the enterococci concentrations for the USGS station at highflow are slightly higher than the tributaries and streams with a range of 69 MPN/100mL to 3800 MPN/100mL.

Groundwater: As shown in **Figure 6.5-15**, the majority of the concentrations of enterococci for the EOFs range from 2200 MPN/100mL to 33000 MPN/100mL. The majority of the concentrations of enterococci for the geoprobe samples ranged between 11 MPN/100mL to 960 MPN/100mL. The majority of the concentrations of enterococci for the spring samples ranged between 4 MPN/100mL to 100 MPN/100mL. The majority of the concentrations of enterococci for the well samples ranged between 1 MPN/100mL to 1.5 MPN/100mL.

6.6.3 Distribution of Potassium and TOC through out the Basin - Water

Surface Water: **Figures 6.6-9** through **Figure 6.6-12** are spatial representations of the average concentration of total organic carbon (TOC) for the various sampling locations. The majority of the locations monitored had concentrations of TOC greater than the reference samples (typically 2.5 mg/L TOC). **Figure 6.6-11 and Figure 6.6-12** indicate that the highflow and baseflow surface water locations in Arkansas tended to have higher concentrations than those sampled in Oklahoma.

As shown in **Figure 6.5-8** and **Figure 6.5-9** (introduced in previous section), the majority of the concentrations of total organic carbon (TOC) range from 7 mg/L to 20 supplied additional information relevant to the evaluation of waste source signatures in the watershed.

The above sensitivity runs relate to the current PCA runs conducted and discussed in this report. However, in addition to these current runs, numerous sensitivity runs were also conducted during previous, preliminary PCA runs. As discussed above, many of these previous runs were repeated in the current runs and are therefore not discussed specifically in this report. On the other hand, some of these previous runs were not repeated, including, for example, the sensitivity on the water PCA of including arsenic and nickel data versus not including these data.

In summary, the sensitivity analyses indicated that the PCA (as established and conducted in this investigation) proved to be very robust and was insensitive to changes in variables, groupings, or other conditions. The PCA is an appropriate method to identify major sources of contamination in the IRW.

Step 15: State and Document Conclusions

Overall, PCA supports the other lines of evidence previously discussed in this section. Major conclusions from the PCA follow:

- PCA identified two major sources of contamination in the IRW: poultry waste disposal and WWTP discharges. Poultry waste is by far the dominant contamination source in the IRW when compared to other sources. Cattle waste contamination was unique from both poultry waste and WWTP discharges; however, contamination from cattle waste is not dominant in the IRW and only represents a minor source.

The overall conclusions of the PCA evaluation in relation to the hypotheses given in section 6.1 follow:

- Land application of poultry waste affects the chemical and bacterial water and sediment composition of the IRW. The affect is observable in surface water, groundwater and sediments collected from the IRW. This is shown by PCA: a large and distinct group of samples is dominated by poultry waste contamination.

- WWTP discharges into rivers affect the chemical and bacterial water composition of the IRW. The affect is observable in surface waters collected from the IRW. This is shown by PCA: a distinct group of samples is dominated by WWTP discharge.

- Cattle manure deposited in fields and rivers affects the chemical and bacterial composition; however, no dominant impact is observed from cattle waste in the PCA. This is consistent with the mass balances.

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6.~~13~~ Conclusions

As discussed in Section 6.2, multiple lines of evidence were used to evaluate the sources of contamination in the IRW. The multiple lines of evidence all support that poultry waste disposal by land application is a major source of contamination including phosphorus and bacteria in the IRW. These lines of evidence include the chemical and bacterial composition of major waste sources compared to contamination in the IRW, mass balance calculations showing that poultry waste is a major source of contamination, fate and transport observations for poultry waste contaminants through out the IRW, analyses and detection of a poultry specific biomarker and PCA evaluations showing poultry waste contamination in a dominant source. These lines of evidence can be used to test the hypotheses stated in Section 6.1. The conclusions concerning the hypotheses follow:

- Land application of poultry waste affects the chemical and bacterial water and sediment composition of the IRW and the affect is observable in surface water, groundwater and sediments collected from the IRW. Poultry waste is the dominant source of contamination in the IRW.

- WWTP discharges into rivers affect the chemical and bacterial water composition of the IRW. The affect is observable in surface waters collected from the IRW. The effect is not as large as the effect of poultry waste disposal in the IRW.

- Cattle manure deposited in fields and rivers affects the chemical and bacterial composition; however, no dominant impact is observed from cattle waste in the PCA.

Table 2.8-6: Summary of the 2007 River and Biological Program Sampling

Parameter Group	Number of Samples collected by Sub-task							Total Number of Samples
	Subtask 1a	*Subtask 1b*	*Subtask 1c*			*Subtask 1d*	*Subtask 2*	
	Pre-survey	Weekly	Intensive	Full Suite	Partial Suite	Biological	Synoptic	
Bacteria				36	2			38
Chlorophyll a, Benthic			414					414
Chlorophyll a, Sestonic			72			38		110
Diatoms			70					70
Benthic Macroinvertebrates			70					70
Estrogens				36				36
Forms Of P		613	70	36	35	37		791
Nitrogen Compounds				36	35	38		109
Chloride				36		38		74
Sulfate				36				36
Dissolved Metals				36				36
Total Metals				36				36
Total/Dissolved Organic Carbon		72	70	36	35	34		247
Total Suspended/Dissolved Solids				36				36
Field PO4 samples	86						99	185